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AN EFFICIENT ENERGY AWARE LINK STABLE ROUTING PROTOCOL IN MANETS

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ABSTRACT

Mobile ADHOC Networks (MANETS) are infrastructure-less wireless networks in which nodes act as both source and router. All the nodes in the ADHOC network have limited battery capacity so conservation of energy becomes an important factor while routing data from a source node to destination node. Wireless links are generally much inferior and less secure as compared to wired one. Frequent link failures result in lesser QoS (Quality of Service) parameters such as lesser throughput, higher end to end delay, higher latency and less utilization of link bandwidth.

The proposed approach will consider the multi-objective function which will consider both energy saving as well as the stability of link while defining a fitness function using a genetic algorithm. The above technique can also be implemented in Vehicular ADHOC Networks (VANETS). Since VANET is a subclass of MANET with the car to car ADHOC networks. VANETS are useful in road emergency situation or in case of inter- vehicle communication.

KEYWORDS: Genetic Algorithm, Energy, Mobility, MANETS, VANETS & Link Stability

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Original Article

INTRODUCTION

MANETS (Mobile Adhoc Networks) are the collection of various nodes which can communicate with each other in the transmission range without any central controller. VANETS (Vehicular Adhoc Networks) are a subclass of MANETS in which car to car Adhoc communication takes place as shown in figure no.1. Since nodes are mobile so it affects the topology of a network. Each node in the network behaves router as well as host. The efficiency and performance of a network depend on how well information is routed from source node to the destination node. Energy is an important parameter to be conserved to enhance network lifetime. Various protocols have been proposed to conserve the energy in MANETS. Mobility of nodes results in network changes so it reduces overall stability of link. Since link stability reduces so it degrades the performance of any routing protocol. Links may be unstable due to wireless properties of the channel. Adhoc Network has constraints such as bandwidth allocation, packet overhead, attacks of malicious nodes, wireless links which may result in the complicated routing process. Earlier proposed work considered either energy or stability of link or bi-objective function considering link stability and energy drain rate of a node. C. K. Toh [1] discussed that power required by each mobile host can be categorized into two main categories as:

- Communication Related Power
- Non Communication Related Power

Communication-Related power is further subdivided into processing power and transceiver power. Each mobile host needs some power to execute network functions as well as transceiver power involves the power consumed by radio transceivers to communicate with other mobile hosts. He told about the shortcomings in minimum hop routing and proposed **Conditional Max-Min Battery Capacity Routing (CMMBCR).** He advised that minimum transmission power path must be selected among routes with battery power above the threshold limit. With the help of Simulations he proved that the power needed for communication- related activities is much greater than non –communication related activities. But he did not consider the residual energy of nodes.

So Kim and Garcia [2] gave a new metric energy drain rate **to** tell about network lifetime according to the current traffic. Drain Rate does not allow all the traffic through one route only because it has sufficient residual battery power. **Minimum Drain Rate (MDR)** enhanced the battery life of nodes as well as a duration of paths. But this metric does not ensure minimum transmission power**.** Conditional Minimum Drain Rate (CMDR) also minimizes total transmission energy consumed per packet.

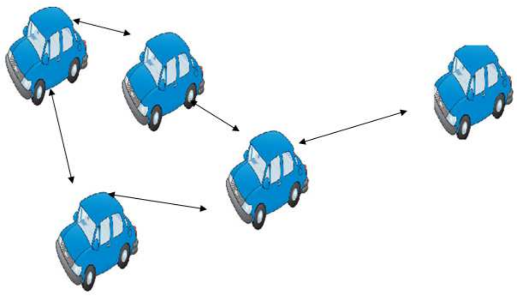

Figure 1: Vehicular Adhoc Networks

LITERATURE SURVEY

In [17] UAV (Unmanned Aerial Vehicle) air networks are highly dynamic. Author has proposed BSCAR (Bionic Optimization based stability and congestion aware routing protocol. He has considered **Ant Colony Optimization** technique for finding congestion aware routing path in traditional DSR algorithm. He has considered three parameters i.e. route length, congestion level of route and stability of route. For finding stability of route link stability is established by measuring received Signal strength of “HELLO” messages. In this paper HELLO packet format includes address of source node, congestion level of node, gain of antenna, transmitting power and speed of node.

In [19] author has reviewed QOS parameters such as bandwidth, end to end delay along with energy constraints. He has considered delay as additive quantity and reviewed delay aware routing protocols such as AODV and DSR. Instead of taking the shortest path as main metric he has considered delay as main metric.

In [18] author has presented Genetic Algorithm to save energy in a multicast tree based Mobile Adhoc Network. Shortest path multicast tree is built to minimize delay time by using a small set of initial population. He has calculated residual energy of all the nodes in multicast tree structure. **Genetic Algorithm** uses the concept of fitness function. Parameter which is to be optimized is defined in fitness function, followed by Cross –over and mutation operators. It is evolutionary algorithm which selects from initial population by ‘natural fittest’ concept. Cross over is mating process in which genes of two parents are exchanged to produce new off spring. Mutation is another genetic operator in which new characters are introduced by modifying genes. In this paper, author has introduced energy efficient based mutation process.

In multicast tree formation we replace nodes with low energy with higher energy nodes. Zafar S. [25] has also used Genetic Algorithm to optimize QOS parameter.

In [6] F. De Rango gave a unique routing protocol which considered both link stability as well as energy aware parameters. He proposed LAER (Link-stability and Energy aware Routing protocols). He considered link stability along with minimum drain rate energy consumption.

In [10] Zhu and Wang told that only considering minimum energy path can result in increased route setup time, more routing overhead and increased routing maintenance issues. They proposed PEER (Progressive Energy Efficient Routing) which results $2/3^{rd}$ path overhead saving and 50% transmission energy savings.

Wu [11] gave a unique routing protocol considering both link stability as well as bandwidth efficiency. The author has used distributed Q-learning for maintaining network status in AODV. In QLAODV, each node exchange HELLO message with neighbor node. Every node calculates mobility factor (MF) and bandwidth factor (BF). Then node maintains Q value, MF and BF. Node forwards the data to next node with maximum Q-value.

Samar and Wicker [13] [14] pioneered the models for analytical evaluation of links dynamics in the optimization of design of any protocol. Samar and Wicker assumed that nodes are moving with constant speed and direction to compute the lifetime of link. Later Wu [12] has computed lifetime of links using two state Markov's model. The author has presented analytical framework as well as simulation results for characterization of link.

Q. Song [15] proposed a new idea to calculate the link stability which is based on link connectivity changes. They used variable size of sampling window in HELLO packet format to estimate the transition rate of a link using Markov's model. Routing scheme (OLSR, AODV, and DSR) changes according to estimated link transition rate. So here link duration is used to assess quality of link. In [21] author has proposed a new model to compute link stability as well as path stability. He has computed MSD (Maximum Stability Duration) of a link i.e. the maximum duration for which link was connected. According to calculated values of MSD he has categorized links as low stability, average stability and high stability. Then he has defined path stability same as low stability path, average stability path and high stability path. He concluded that path stability closely follow link stability. He also found that proactive routing protocol has more number of low stability paths in comparison to medium or high stability paths.

Ali Moussaoui [16] presented a unique idea to select MPR (Multi point Relays) in proactive routing protocol such as OLSR. He has calculated SND (Stability function of Nodes) and FND (Fidelity function of Nodes). Then he has chosen the path among two nodes with minimum value of SND which is largest among all candidate paths. As number of nodes increases value of calculations involved in selecting MPR in proposed OLSR routing mechanism is greatly reduced. This method improves QOS (Quality of Service) parameters such as packet loss and response time.

In 2016 Malathi [22] proposed a routing protocol which is robust in route failure. As author has considered three important parameters i.e. quality of channel, quality of link as well as energy level of node. Since channel is the medium through which information travels. So channel capacity is calculated then link is measured using link life time and then residual energy of nodes is considered. So proposed scheme results in less number of route failures by taking into consideration all three parameters i.e. channel quality, link quality and residual energy of nodes.

Mammar S. [23] has enhanced traditional routing method AODV by predicting link failure to enhance QOS. He has predicted link failure by measuring signal strength which will optimize link management and reduces the link failure

rate. He has suggested PF_AODV (Predict Failure AODV) by measuring link strength. If link is going to break then another link from link cache is chosen. Simulations prove better results as compared to AODV.

Sarma and Nandi [24] have suggested route stability method to enhance QOS. The author suggested RSQR (route stability based QOS routing) in MANETS. Probability of route failure can be reduced by reducing rate of link failure. Longer links are more unstable as they come near to radio range. So there is a compromise between shortest paths with longer links (unstable) or longer routes with stable links. In RSQR each node computes available bandwidth at the node by subtracting bandwidth from aggregate B.W. Then most stable path from source to destination is chosen which satisfies minimum bandwidth with maximum delay.

In MEA-DSR [20] author has extended DSR protocol packet format to make it energy efficient. He has modified DSR header packet and included cost function both in route request as well as route reply packet. The path according to minimum cost function are organized from best to worst path. He has computed many node disjoint paths out of which most energy efficient path is chosen. Since node disjoint provide higher fault tolerance. In non disjoint routes link or node failure causes many routes to fail. Whereas in node or link disjoint routes link failure will cause only single route to fail.

Another approach to improve routing efficiency is to use multi path in comparison to single path. More than one path is used to increase routing efficiency. Multiple paths can be link disjoint or node disjoint. In link disjoint paths goal is to reduce delay and increase efficiency. Multipath AODV or Multipath OLSR is proposed to prove it.

PROPOSED WORK

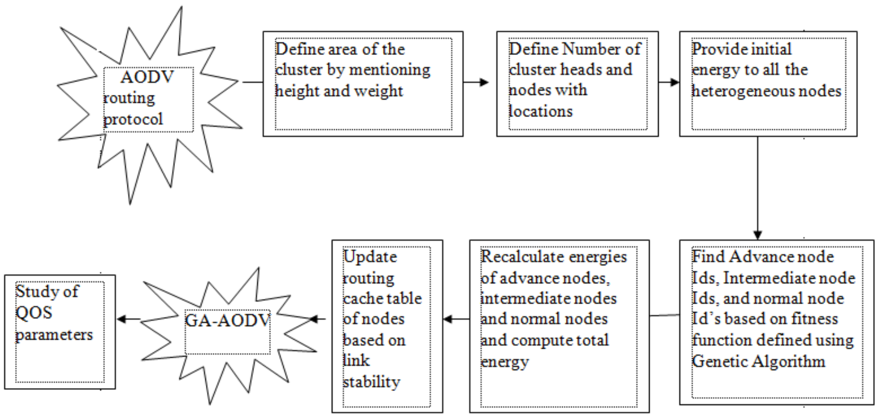

Figure 2: Proposed GA-AODV Architecture

Clustering

Clustering helps to increase the scalability of a network for the large number of nodes. Divide the network into the disjoint or overlapping group of nodes. These groups of nodes are called clusters. There is a special node in each group known as Cluster Head (CH). Cluster Head is the main co-coordinator of the cluster. Reset all nodes are member nodes. Member nodes pass their information to the cluster head. Gateway nodes help to exchange information between two clusters. Various algorithms have also been proposed for choosing CH (cluster head) in MANETS. In LCA (Linked Cluster Algorithm) a unique ID is provided to each node. The node which is having highest ID among the neighbors is chosen as CH. In WCA (Weighted Cluster Algorithm) each node is assigned some weight based on metrics such as battery power. Below mentioned are different Metaheuristic Techniques to choose Cluster Head.

- ACO (ANT COLONY OPTIMIZATION)
- PSO (PARTICLE SWARM OPTIMIZATION)
- GA(GENETIC ALGORITHM) Based on Evolutionary process
- Fuzzy Network induced optimization

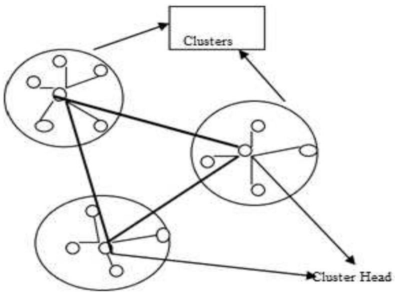

Figure 3: Clustering in MANETS

In this work, Genetic Algorithm is chosen as shown in Figure No. 2 over other metaheuristic techniques such as Ant Colony Optimization, Particle Swarm Optimization and Fuzzy networks because GA works on the set of a population rather than working on the single set of individuals. Another important reason is that GA tries to converge for global optima rather than setting for local optima. Network scenario is divided into clusters as shown in Figure No. 5. All the operators of Genetic Algorithm such as population initialization, Fitness Function, Cross –Over and Mutation are explained in detail in the upcoming section.

GENETIC ALGORITHM

Genetic Algorithm [18] was invented by John Holland in 1975. There are mainly two types of approaches that are used in route selection.

- Deterministic Approaches
- Heuristic Approaches

For deterministic approaches, only single route tree is formed for any given route discovery process. Using heuristic approaches many route trees are formed and best solution is selected. Genetic Algorithm [31] is chosen over other heuristic techniques because it works on the population of feasible solutions rather than working on the single set of solution. It generates an optimum solution by generating different individuals as each generation has better-evolved chromosomes.

Basic operations in genetic algorithm include initialization of population, calculating fitness using fitness function [32], selection, and crossover, mutation [33], updating of optimal chromosomes and checking for the termination condition.

Fundamentals of Genetic Algorithm

Initialization of Population

Genetic Algorithm [34] starts with an initial population comprising random chromosomes which is a sequence of 0's and 1's. In case of steady- state GA, one or two members of a population are replaced while in generational GA all the

members of the population are replaced.

At every step, current generation creates the population for next generation. Parents are selected on the basis of their fitness count. Genetic Algorithm creates three types of children as

- **Elite Children**: Individual with the best value of fitness score are promoted to next generation.
- **Cross –Over Children**: Children formed by combining parents based on their fitness value.
- **Mutation Children:** Children formed by mutation or random changes in a single parent**.**

Fitness Parameter

Fitness Function is the process of scoring chromosomes on the basis of fitness value. Based on the fitness value next generation evolves. At the command line, we write MATLAB code, [x fval]=ga(@fitness function, nvars, options)

Where @fitness function is a handle to the fitness function, nvars is the number of independent variables, options is the structure having options for Genetic Algorithm. Function returns the fval (fitness value) at point x. Additional output arguments can be passed using syntax [x fval reason output population scores]=ga (@fitness function, nvars) where reason gives the terminating conditions for the algorithm. Output gives information about the performance of the algorithm. Population, scores tell about final population and final score.

Ga Tool

Ga tool is a graphical user interface that allows the user to work directly without using the command line. Objective function that we want to minimize is mentioned in a fitness function. Numbers of variables define the length of input vector of a fitness function.

But Genetic Algorithm [35] is not suitable for problems which require repeated fitness function calculation. Some optimization problems require several days to give an exact solution. Genetic Algorithm has the tendency to converge for local optima [29] rather than working for global optima. It is difficult to operate on dynamic data sets since genomes converge early on getting solutions which is not valid for later data sets. GA is also not effective where there is no way towards convergence; in that case, random search yields a better solution.

Stopping Conditions of Algorithm

Genetic Algorithm checks for either following conditions to terminate:

- Maximum Number of generations
- Stall Generations
- Maximum time limit
- Maximum limit of fitness
- Stall time limit

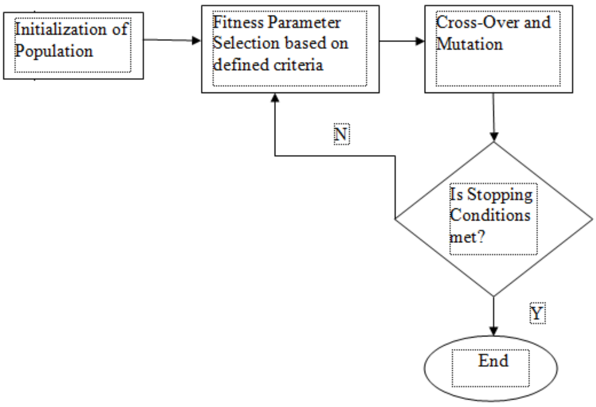

Figure 4: Genetic Algorithm

As shown in Figure No. 4 fitness criteria selected for this work is a residual energy of node. Node Id's which are having higher values of residual energy are advance node Id's as shown in Figure No. 5. After considering the energy node those links will be considered which give minimum value of congestion aware fitness function as defined by equation no.(5). Link stability is checked by measuring received signal strength from the physical layer.

Link Stability

Link stability can be calculated by discarding links with lesser values of signal strength by obtaining received signal strength from physical layer.

$$Q\_L = Pt\ (/ 4*\boldsymbol{\pi}*d^2).\ Gt.Gr \quad (1)$$

Where Pt = Transmission power of node

λ = Wavelength of Carrier

d = distance between sender and receiver node

Gt, Gr = Unity gain of transmitting and receiving antenna

Q_L = Quality of link

MAC Overhead

IEEE 802.11 MAC with distributed co-ordination function (DCF) is considered. Channel Occupation due to MAC contention is given as:

$$Ch\_MAC = T_{RTS} + T_{CTS} + T_{SIFS} \quad (2)$$

Where T_{RTS} = time consumed by request to send packet

T_{CTS} = time consumed by clear to send packet

T_{SIFS} =Short Inter Frame Space Period

MAC Overhead is given as

$$MAC\_overhead = Ch\_MAC + ta \quad (3)$$

Where ta = time taken due to access contention

Data Rate Estimation

Since in MANETS throughput depends on minimum data rate of entire link. Packet Congestion occurs when node with high data rate forwards traffic to node with low data rate.

Data_rate = Data_size / channel_delay (4)

Fitness Function

Congestion aware fitness function= 1/Q_L* MAC_overhead *Data_rate[gi(j), gi (j+1)] (5)

Where j is the next chromosome.

Algorithm

Step 1: Initialize the area of the network.

Step 2: Initialize height and width of cluster.

Step 3: Mention the location of source node.

Step 4: Mention the number of cluster heads in specified box

Step 5: Define the number of nodes with specified location

Step 6: Provide initial energy to all heterogeneous nodes.

Step 7: Find Node Id's with advance energy, intermediate energy and normal values.

Step 8: Calculate the value of total energy. Advance node Id's with higher values of energy is selected.

Step 9: After topology is built, apply congestion aware fitness function.

Step 10: Links with minimum value of congestion aware fitness function is selected.

RESULTS AND DISCUSSIONS

Network Scenario generated during simulation is shown in Figure No. 5. Nodes are divided into clusters. Based on values of residual energy nodes are classified into an advance node, intermediate node etc. as shown in Figure No.6. Distribution of energies of different nodes is shown by Figure No. 7.Nodes with a higher value of residual energy is considered into routing. Further with the minimum value of congestion aware link parameter, stable links are considered.

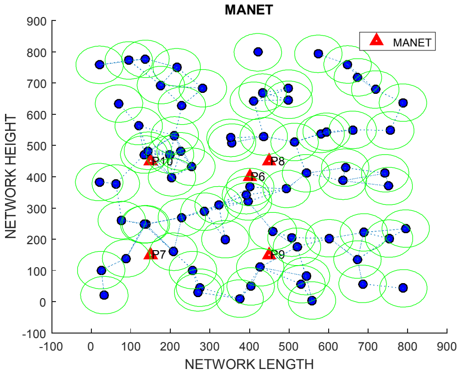

Figure 5: Network Topology during Simulation

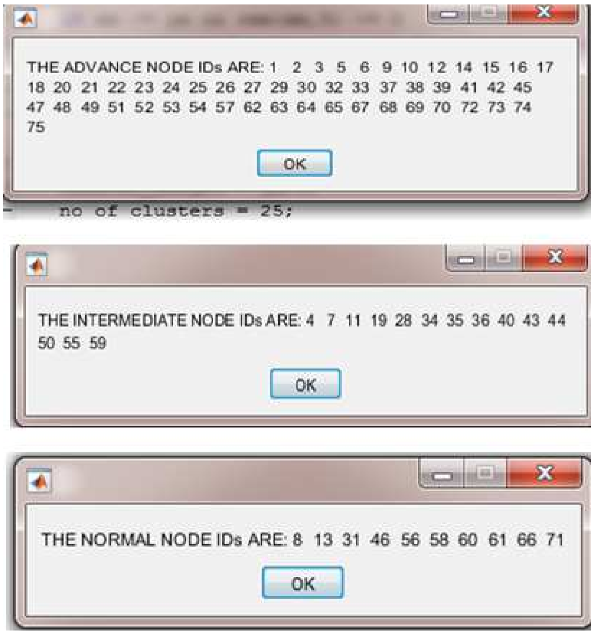

Figure 6: Advance, Intermediate, Normal Node Id's Based on their Energy Levels

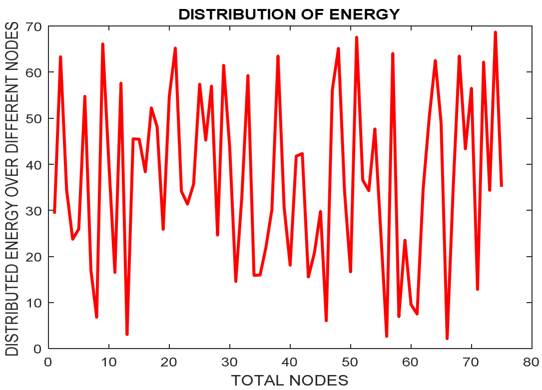

Figure 7: Distribution of Energy over Nodes

Performance Metrics

Throughput

It is the measure of the rate of message transfer over the channel. It is measured in Kilobits per second (Kbps). This parameter used to tell how fast node can sent data in a network.

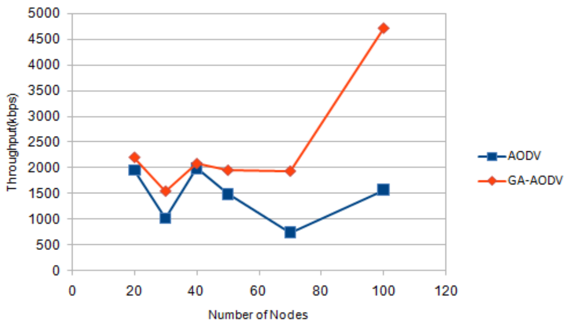

Figure 7: Throughput Comparison

Above Figure No. 7 suggests that as scalability of the network increases the throughput of GA-AODV is much better than AODV. This is because better wireless links are chosen in case of GA-AODV.

End to End Delay

It is the total time taken from source node to destination node.

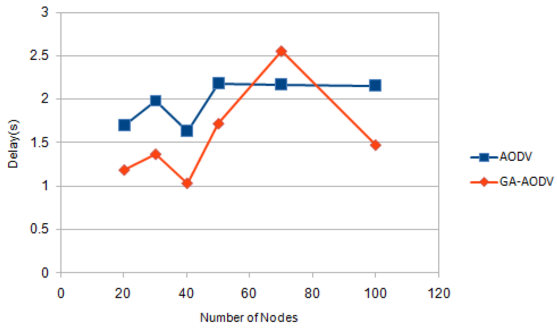

Figure 8: End to End Delay

Figure No. 8 suggests that End to End delay of GA-AODV is greatly reduced since stable paths are chosen over fragile ones.

CONCLUSIONS AND FUTURE SCOPE

GA-AODV outperforms AODV in terms of QoS parameters as energy conscious nodes are considered while routing as well as stable wireless links are chosen over fragile ones. Energy spent by nodes in Vehicular Adhoc Networks or in MANETS can be further optimized with the help of other heuristics techniques such as fuzzy control, ACO etc.

BOOK

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